term is demonstrated by Motorola's suggested definition for "passable" as being the "level of interference which still, however, provides a fully viewable picture..." (Motorola A3-3). A "fully viewable picture" could be one with highly annoying interference content but where the action in the picture could still be followed. The term is ambiguous as defined by Motorola and should not be substituted for the agreed term "acceptable."

The 20 dB adjustment factor espoused by land mobile interests for linear interference is broken down into three factors: (1) 10 dB to adjust from gray field to program content; (2) 4 dB to adjust from expert to nonexpert viewers; and (3) 6 dB to adjust from just perceptible to acceptable or passable (LMCC A-16; Motorola A3-3). Motorola states also "The results of our own laboratory and theoretical analysis are consistent with these factors..." (A3-3). No underlying data or test methodology have been provided by Motorola.

The 10 dB correction factor, based on no data so far revealed outside the land mobile community, if indeed such data exist, contrasts with the 5.2 dB obtained from the CTC tests made following protocol approved by the entire TAC Working Group and openly conducted with observers invited to appear. In this context, a comment in the draft FCC Laboratory report on receiver tests (TAC Document WG-1.3) is of particular interest. In that report, the statement is made, "We have found that when a

50 IRE flat field is compared to program material on the desired video modulation, results for "just perceptible" interference are usually with(in) plus or minus 4 dB." The conclusion to be drawn from that statement is that perhaps no adjustment at all should be made for this factor. Furthermore, limited observations made by land mobile and broadcasting representatives at the CBS Technology Center prior to the formal commencement of tests provided varying results for the perceptible-acceptable factor depending upon the location of the land mobile interferor in the television pass band. Near the picture carrier, no difference was found between just perceptible interference in a 50 IRE gray field and in program content. At some locations in the television pass band, interference was perceived in program material before it was seen in the gray field. This indicates that 5.2 dB is a generous adjustment.

As discussed previously, with respect to the CTC tests, no adjustment for expert to nonexpert viewers is justifiable.

The 6 dB factor has not been shown to be based upon any kind of a systematic test. It is known that observations were made at CTJC using real time programming, but insofar as is known, no tests were conducted in a fashion which is justifiable from a statistical viewpoint. The use of real time programming means that no test can be repeated and each interference level is being judged against different program content. The CTC tests which were conducted by experts in a manner with scientific validity, yielded a factor of 1.6 dB for the conversion of "just perceptible" to "acceptable" in program content.

TV Receiving Antenna Discrimination

LMCC (paragraph 17) and Motorola (Appendix 6) rely upon a 1981 report by the Canadian Department of Communications (DOC) and a 1964 report by the British Broadcasting Corporation (BBC) to justify a 20 dB factor as an adjustment to account for directivity and polarization discrimination of the television receiving antenna. Neither report provides a proper basis for drawing such a conclusion.

The DOC employed two UHF-only antennas for its testing in the vicinity of Sarnia and Chatham, Ontario. The antennas are not typical for the American viewing public, nor is the terrain in the Sarnia/Chatham area in any way an average for the United States.

The two antenna types employed were a corner reflector and a "bow tie" in front of a screen. Although such antennas can be found in use by television viewers, the far more common antenna employed is the all-band VHF/UHF type. The latter antennas generally have lower front-to-back ratios than the former types so the directional patterns can be expected to be quite different.

Polarization discrimination is greatly affected by terrain and foliage. The area in Ontario where the tests were conducted is characterized by very flat terrain and although the exact degree of forestation is not known, it is known that the area is not heavily forested and maps of the area indicate just patches of trees.

The BBC tested a television receiving antenna consisting of a Yagi antenna in front of a ground screen, an antenna not usually found in homes in the United States. In addition, the television receiving antenna was vertically polarized and the undesired signal was horizontally polarized. At page 11 of its report, the BBC suggested it would be desirable to test the opposite configuration. That opposite condition is, of course, the one that is most pertinent to the present situation. Furthermore, the BBC noted considerable difference between nearby locations which were within line of sight and distant locations in the diffraction zone. In considering interference near the Grade B contour of the television station, it is the diffraction zone that is most important and that is the region where the least discrimination was found. In consideration of the fact that the antenna type is not typical, the polarization of the desired and undesired signals was opposite what is here needed, and the region of most interest shows considerably lower discrimination than the average, the BBC report does not support a 20 dB discrimination factor.

In its Appendix 6, Motorola alleges that a test made at its plant in Schaumberg, Illinois, on two corner reflector antennas and one all band antenna, supply support also for the 20 dB factor. However, details of the test, which would permit independent judgment, are missing. The initial part of the test involved a source antenna on the ground and the test antenna on a tower, with the intent of simulating free space conditions. No dimensions are provided to indicate the distance between the source antenna and the test antenna. The sketch provided would appear to indicate that when the antenna is rotated the electrical center of the antenna is varied in position with respect to the source antenna. Depending upon the distance between the two antennas and the manner of mounting, this factor could modify in a significant way the plotted radiation pattern.

With the antenna mounted on top of the tower at a height of about 35 feet, the antenna was said to be in a multipath environment because the antenna range "is bordered by trees, power lines, light poles, radio transceiving towers, and building." No information is supplied as to the distances or characteristics of these reflecting sources. No judgment can be made as to whether the conditions on the test range are at all comparable to what might be expected in a typical home receiving situation.

As pointed out in the engineering statement supporting the MST Comments, broadcasting and receiver industry representatives in the TAC Technical Analysis Working Group believe that the entire Working Group had agreed upon support for the 10 dB discrimination factor which had been proposed by the FCC. Because of that belief, the statement was made in open meeting that further testing would not be done by the Working Group. Motorola, a full participant in the Working Group, now offers the results of a privately made test and does not even support that test with full documentation. No credence can be attached to such material.

Results of Present Sharing of UHF Television Channels by Land Mobile

LMCC (paragraph 23), Motorola (pages 7 & 8), and NABER (page 8) allege no awareness of interference being caused to UHF television reception from present sharing by land mobile interests. NABER alleges that the use of the 40 dB criterion for cochannel interference in the New York, Cleveland and Detroit markets has apparently not caused interference to television reception. However, no interference is to expected in any of these situations. Land mobile use of UHF television channels has not occurred in Cleveland and Detroit because of resistance on the part of Canada. In New York, interference would not be expected because of the particular circumstances involved.

The cochannel station which would be affected by land mobile use of channel 15 in New York is WLYH-TV, in Lancaster, Pennsylvania. WLYH-TV operates with effective radiated power of 1050 kilowatts at an antenna height above average terrain of 1360 feet. The separation between the New York reference point and the WLYH-TV transmitter is just over 133 miles. On the direct bearing toward New York, the distance to the WLYH-TV Grade B contour is 47 miles, thus being 86 miles from the New York reference point. If a land mobile base station were to operate 90 miles from WLYH-TV, FCC rules would limit that operation to effective radiated power of 50 watts at a height of 250 feet. With such an operation, the f(50,10) signal strength of the land mobile at the WLYH-TV Grade B contour would be 6 dBu. Since the Grade B contour of UHF stations is the 64 dBu, the desired-to-undesired ratio would be 58 dB. A ratio of 58 dB D/U is 6 dB better than the 52 dB that MST proposed in its Comments. The absence of complaints under such circumstances is not surprising.

No matter that the situation between Lancaster and New York would not be expected to generate complaints, the use of the spectrum should not be based upon such unreliable data as whether or not complaints have been received specifically attributing interference to land mobile transmissions. The protection to be afforded in either intraservice or interservice sharing should be based upon scientifically conducted, statistically valid tests. Furthermore, for regulations intended to be employed for years to come, consideration must be given to likely changes in receiving equipment.

Impact of Varying D/U Ratio on UHF Television Interference

In an attempt to support a conclusion that land mobile operation in the UHF band results in little interference to UHF television reception, Motorola provides a mathematical analysis of a "worst case situation" (A-15). The operation of WMPT, Annapolis, Maryland, on channel 22 with effective radiated power of 5 MW and antenna height of 870 feet above average terrain, was selected as the victim station and a multi-transmitter land mobile station operating with maximum facilities (1 kW at 500') was assumed. Those choices for television and land mobile facilities are quite reasonable but the selection of a totally inappropriate receiver protection factor R(Q), removes all meaning from the results. For R(Q), Motorola employed a factor of only 20 dB. To a 40 dB D/U ratio said to be appropriate for the median receiver, an additional antenna discrimination factor of -20 dB was applied. As noted in the MST Comments and herein, a 20 dB D/U ratio falls 32 dB below the ratio needed for UHF television protection.

A mathematical analysis of the impact on UHF television reception of employing different D/U field strength ratios has been prepared by John C. Kean, a senior engineer in the office of Jules Cohen & Associates, P.C. Employed in the analysis is the factor for receiver susceptibility to cochannel interference determined from the most recent FCC, NAB and CTJC tests reported by the TAC. The analysis follows.

Calculations of the Probability of Land Moble Interference to UHF Television Service

The following addresses the potential impact of land mobile base transmitters on UHF television reception at the Grade B service contour assuming the statistical variabilities of time and location set forth in the FCC OST Bulletin TM 82-2. The calculations show the percentage of interference to service located in the "nearest square mile," that is, the area just within the Grade B contour at the closest point to the land mobile interferor. Calculations are based on a desired-to-undesired field strength ratio of 52 dB at the TV receiving antenna. That ratio was derived from recent laboratory tests of "acceptable" picture quality and 10 dB of receiving antenna discrimination.

Three of the calculations herein predict the interference resulting from particular desired-to-undesired field strength ratios, while another calculation shows interference to an actual UHF television station based on a land mobile site proposed by the Commission. The probability of interference calculated herein shows the potential for major loss of television service if protection requirements are adopted as proposed.

Interference protection ratios are expressed in terms of a desired-to-undesired ratio, employing the pertinent f(50,50) field strength value for the desired signal and the f(50,10) field strength value for the undesired signal. For example, the 40 dB D/U ratio proposed by the Commission is related by

$$Fd(50,50) - Fu(50,10) = 40.0 \text{ dB}.$$

At the UHF-TV Grade B contour, the field strength is defined to be 64.0 dBu. Transposing the terms, then

$$\begin{aligned} Fu(50,10) &= Fd(50,50) - 40.0 \text{ dB} \\ &= 64.0 \text{ dBu} - 40.0 \text{ dB} \\ &= 24.0 \text{ dBu} \end{aligned}$$

The distance to the 24.0 dBu interference contour for a land mobile (LM) base station with effective radiated power (ERP) of one kilowatt at 500 feet effective antenna height (HAAT), as determined from the UHF-TV f(50,10) field strength curves, is 74 miles. This is the distance for a field strength exceeded at 50 percent of locations at least 10 percent of the time. From UHF-TV f(50,50) curves, the field strength for the same locations at least 50 percent of the time is 10.4 dBu.

From OST TM 82-2, equation (4), the standard deviation of time variability for the undesired signal is .

$$\begin{aligned} su(T) &= [f(50,10) - f(50,50)] / 1.282 \\ &= (24.0 - 10.4) / 1.282 \\ &= 10.6 \text{ dB} \end{aligned}$$

For a desired, UHF-TV station of 5 MW at 870 feet effective antenna height, the standard deviation of time variability is

$$\begin{aligned} sd(T) &= (35.7 - 27.0) / 1.282 \\ &= 6.8 \text{ dB} \end{aligned}$$

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In the presence of an undesired signal u, interference to a desired signal d is presumed when

$$Fd - Fu < R(Q)$$

where Fd = field strength of the desired signal in dB

Fu = field strength of the undesired signal in dB

$R(Q)$ = protection ratio in dB of the desired to undesired field strength at the receiver site to provide a given service quality (in this case, 52 dB)

Assuming Fd and Fu are independent, normally distributed random variables, the probable desired-to-undesired field strength ratio in dB (Fd - Fu) for L-percent of locations and T-percent of time is (from OST TM 82-2 equation 10)

$$Fd-Fu = Fd(50,50)-Fu(50,50)+k(T)\ sd(T)^2+su(T)^2 + sd(L)^2+su(L)^2$$

At the interference contour, where $Fd - Fu = R(Q)$ for $100xP_I$ percent of locations and ten percent of time,

$$k(P_I) = \frac{Fu(50,50)-Fd(50,50)-k(10)\sqrt{su(T)^2+sd(T)^2}+R(Q)}{\sqrt{su(L)^2 + sd(L)^2}}$$

where $k(P_I)$ is the standard variate for normal distributions of a given probability.

Solving for the 40 dB D/U case

$$k(P_I) = \frac{10.4 - 64.0 - (-1.282)\sqrt{10.6^2 + 6.8^2} + 52}{\sqrt{12^2 + 12^2}}$$

$$= 0.857.$$

From a normal probability function table, the probability associated with a given standard variate for normal distributions is

$P_I = 0.806.$

The probability of service by time is defined to be 50 percent, hence

$P_S = 0.500.$

The joint probability of service and interference is thus

$$P_J = (P_S, P_I)$$
$$= (0.500,\ 0.806)$$

By interpolation from the bivariate normal distribution table listed in subroutine PJOINT (part of computer program TVINT), the probability of interference to service is 0.325, or 32.5 percent. In other words, 67.5 percent of service is without interference within the "nearest square mile" under conditions described above.

Solutions by the preceding method for other D/U ratios also show for significantly large probabilities of interference:

for 45 dB D/U,

Fu(50,10) = 64.0 - 45.0 = 19 dBu;

the 19 dBu, f(50,10) distance for 1 kW ERP at 500' HAAT is 91 miles;

the f(50,50) field strength at 91 miles is 5.0 dBu;

therefore,

$su(T) = 10.9$ dB
$sd(T) = 6.8$ dB

$k(P_I) = 0.558$

$P_I = 0.718$

$P_J = (0.500, 0.718)$

$= 0.258$ (25.8% interference to service)
(74.2% service without interference)

for 50 dB D/U,

$Fu(50,10) = 64.0 - 50.0 = 14.0$ dBu;

the 14 dBu, f(50,10) distance for 1 kW ERP at 500' HAAT is 107 miles;

the f(50,50) field strength at 107 miles is 1.8 dBu;

therefore,

$su(T) = 9.5$ dB
$sd(T) = 6.8$ dB

$k(P_I) = 0.282$

$P_I = 0.619$

$P_J = (0.500, 0.619)$

$= 0.192$ (19.2 % interference to service)
(80.8% service without interference)

The same methodology is applied next to WUHQ-TV, Battle Creek, Michigan (cochannel to proposed land mobile base operation in Chicago on UHF-TV channel 41). WUHQ-TV is located approximately 121 miles from the Chicago reference point. Due to its adjacency to Lake Michigan, the base stations cannot operate closer than 121 miles from WUHQ-TV.

Note that at this distance the D/U ratio is approximately 40 dB (64.0 - 24.5 = 39.5 dB).

distance to TV Grade B = 48.5 miles [f(50,50) = 64.0 dBu]
[f(50,10) = 71.5 dBu]

distance from land mobile reference site
to TV Grade B = 72.5 miles [f(50,10) = 24.5 dBu]
[f(50,50) = 10.8 dBu]

su(T) = (24.5 - 10.8) / 1.282 = 10.7 dB

sd(T) = (71.5 - 64.0) / 1.282 = 5.9 dB

$$k(P_I) = \frac{10.8 - 64.0 - (-1.282)\sqrt{10.7^2 + 5.9^2} + 52}{\sqrt{12^2 + 12^2}}$$

$$= 0.852$$

$$P_I = 0.807$$

Interference to the "nearest square mile" is, then

$$P_J = (0.500,\ 0.807)$$

$= 0.326$ (32.6% of interference to service)
(67.4% of service without interference)

While the preceding calculation assumes interference from only a single land mobile interferor, it is likely that numerous base stations could operate simultaneously within the frequency band associated with a 52 dB susceptibility ratio.

Therefore, the following calculation employs the previous conditions with a 5 dB adjustment in receiver susceptibility to account for increased interference.

$$k(P_I) = \frac{10.8 - 64.0 - (-1.282)\sqrt{10.7^2 + 5.9^2} + 52.0 + 5.0}{\sqrt{12^2 + 12^2}}$$

$$= 1.15$$

$$P_I = 0.875$$

$$P_J = (0.500, 0.875)$$

$= 0.384$ (38.4% of interference to service)
(61.6% of service without interference)

Jules Cohen, P.E.

Subscribed and sworn to before me this 29th day of August, 1986.

Anne Mazor
Notary Public, D.C.

My commission expires
October 31, 1986

(SEAL)